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Laboratory Biosafety Status in Ethiopia

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Abstract

Globally biosafety during laboratory work and transfer of laboratory materials from one place to another is critical to prevent unintentional exposure to pathogens and toxins, or their accidental release in to the environment. Biosafety program plays pivotal role in the control of potentially harmful biological agents. There is enormous gap in biosafety use and applications between developed and developing nations. The aim of the present study is to review status of laboratory biosafety in Ethiopia. In the country, laboratory biosafety issues have been given less attention to safely conduct. The review was carried out using resources such as Pub-med, Google and Google scholar data bases. Additionally, Reports and Manuals from laboratories and libraries were explored. In Ethiopia, concerning biosafety, the following basics are lacking or not appropriately functioning and need serious attention. Standard biosafety devices and consumables, appropriate personal protective equipment, and appropriate or qualified biosafety officer in each laboratory are a top priority to ensure laboratory biosafety. Regular training on biosafety for biosafety officers, researchers and regulatory bodies is very demanding. Enforcing the existing biosafety rules and regulation, and coping with the international standards need due attention in the country. Establishment of standard national level biohazard waste disposal is required. Generally, to address the biosafety issues, proper attention and contribution from policy-makers, researchers, laboratory technologists, custodians, and other stakeholders are highly recommended.

Key words: Biosafety; Biological agents; Enforcing; Ethiopia; Guideline; Laboratory.

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1. Introduction

Laboratory biosafety refers to the containment principles, techniques and practices that are implemented to prevent unintentional exposure to pathogens and toxins, or their accidental release into the environment [1]. With the increasing number of countries adopting molecular tools and techniques in their life science research and clinical activities especially in the areas of agriculture and medicine, the biosafety issues are gaining importance to ensure biological safety for the public and the environment [2]. Laboratory workers are exposed to a variety of potential work-related health risks that include infectious materials and cultures, radiation, toxic and flammable chemicals, as well as mechanical and electrical hazards. Biosafety during laboratory work and the transferring of laboratory material from one place to another is a critical tool in the global fight against infectious diseases. Laboratory personnel, particularly those working in microbiological laboratories, are exposed to biohazards which may result in laboratory- acquired infections [3]. Despite the fact laboratory biosafety is top most priority in developed countries; it is often neglected in developing countries like Ethiopia. To conduct research and clinical activities in a safer manner is not only personal requirement but essential collective efforts to ensure biological safety for a clean and safe environment. This certainly requires rules, regulations, monitoring bodies and awareness among the public [4]. Ethiopia lack detailed legal framework for laws and regulations, and lack effective enforcement for laboratory biosafety. Currently in the country, biosafety is at infantile stage, and requires an attention at the grass root level [5]. Hence, the aim is to review the status of laboratory biosafety in Ethiopia using some developed and developing countries reference data.

2. Methods

A systematic literature review was performed from May through July 2019. Research questions and search strategy were developed and discussed. Relevant literatures were then identified through a comprehensive search across different data bases including Pub-med, Google, and Google scholar and, also manual (by hand) search of Reports and Manuals from laboratories and libraries in Ethiopia. We used specific key words that include safety, biosafety, laboratory, developed, developing, country and Ethiopia. The number of papers included in this review was 26, constituting of 10 full articles, 8 manuals and 8 reports. Full-text articles were assessed by 2 authors (Dassalegn D, Kefyalew N). Steps of the review conducted were presented by figure1.

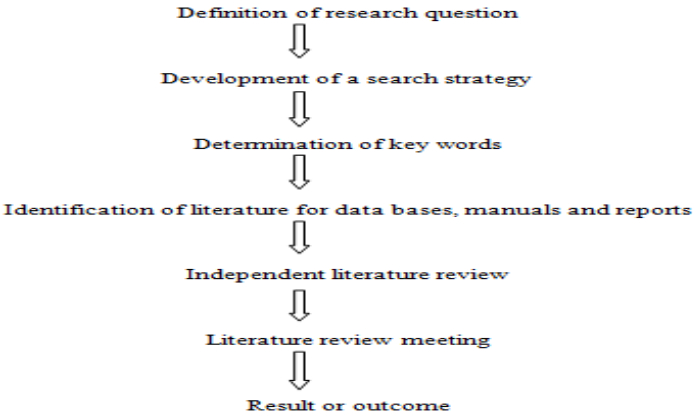

Figure1: Steps in performing literature review on laboratory biosafety status in Ethiopia.

3. Results and discusion

3.1. Biosafety in Germany

Biosafety directives in Germany are more stringent and detailed than European Union (EU) directives. The Biosafety in Microbiological and Biomedical Laboratories (BMBL) was a starting point for these directives, and additional requirements were added to enhance safety. Also pathogenic organisms that arise from laboratories categorized based on their risky group; their handling is agreed with the code of Biological Agents Ordinance. This ordinance was issued and controlled through Central Committee of Biological Safety of the country. There is a clear line of responsibility and authority throughout the country in creating safety culture. In the country, Project leaders and Biosafety Officers are fully responsible for risks and hazards, and such authority is given by law to enlist all measures needed to reduce risk to staff and the environment. Both Project leader and biosafety officer are appointed by the government with the minimum requirements that they hold a degree in relevant profession and ample experience on hands. For-instance, the role of biosafety officer is to supervise project safety and the institution in all concerning biosafety questions. The annual report of the biosafety issues goes to the institution's director and the government. Those directives assist the government to inspect facilities and work areas of the institution, and give certification. Before working with pathogens, laboratory workers attend training and use appropriate Personal Protective Equipment (PPE) and biosafety cabinets [6].

3.2. Biosafety in Switzerland

In the country, handlings and transport, on release of organisms are regulated by a federal law. The rule stipulates that organisms, their metabolic products or waste cannot endanger people, animals or the environment and requires a risk assessment focused on both the individual and organism. Therefore, any person who carries out an activity in contained systems with genetically modified or pathogenic organisms of classes 3 and 4 must guarantee legal liability of 20 million francs to cover damage to persons and property; and of 2 million francs to cover the environment damage. This measure assigns financial responsibility to the whole working with wild-animals and genetically modified pathogens in risk group 3 and 4, and provides responsibility for everyone to protect worker, community, or environment from harm. For-instance, according to ordinance of the country, Highly Pathogenic Avian Influenza Virus (HPAIV), Severe Acute Respiratory Syndrome (SARS-CoV) and Middle East Respiratory Syndrome (MERS-CoV) viruses are considered as risk group 3 or 4. The viruses have increased transmissibility among mammals, and result in accidental release into the environment. The authorized person or biosafety officer approves biosafety preconditions before work can begin. Moreover, laboratory facilities and availability of PPE are abundantly applied [7].

3.3. Biosafety in China

China's biosafety policies were consolidated and made more comprehensive after Severe Acute Respiratory Syndrome (SARS), specifically after a laboratory-acquired SARS infection in 2003. SARS outbreak was the prime motivator for implementing legislation, developing enhanced safety programs, and constructing modern containment laboratories that meet international guidelines. SARS is a serious form of pneumonia and causes

acute respiratory distress (severe breathing difficulty) and sometimes death. SARS is caused by SARS-Corona virus (SARS-CoV) and the virus spread from small mammals. There is currently no treatment for SARS, but research is ongoing to find vaccine. The spread of the virus is preventable through avoiding travelling to areas where there is an uncontrolled SARS outbreak; avoid direct contact with infected people until at least 10 days after their symptoms have gone, and good personal hygiene practices [8]. Biosafety issue is the responsibility of officials, experts, and scientists who specialize in laboratory biosafety. A number of governmental agencies have biosafety responsibility in China, particularly for laboratories. Biosafety manuals, policies and training are rigorously applied; safety equipment is maintained and certified; PPE is abundant. Biosafety committees are available in each Chinese biosafety laboratory. The laboratory leader is responsible for organizing risk assessment and establishing standard operating procedures (SOPs). Staff working in biosafety laboratory must attend training on how to operate equipment correctly to avoid creating an aerosol and how to decontaminate equipment and the laboratory space before working with pathogens. Appropriate primary containment (biosafety cabinets) and PPE are routinely used. Biosafety cabinets are certified annually by independent third-party professional [9].

3.4. Biosafety in Singapore

Singapore has made great progress in biosafety in just a decade to include enacting the Biiological Agents and Toxins Act (BATA) to address biosafety and security of pathogens. Ministry of Health Biosafety Branch was independently established to certify laboratory biosafety and safety programs, and emergency preparedness. The BATA regulates the possession, use, import, transfer, and transportation of biological agents and toxins that are known to be hazardous to human health. According to the regulation, “any person who transports agents must attend hazardous materials transport training course and certified for transport permit.” The biological safety officer is responsible to advise each head of institution or company in all biosafety matters. Also, regular safety audits and supervision for relevant pieces of equipment has carried out by biosafety officer. In general, laboratories and safety programs are on similar footing to those in countries with well-established biosafety legislation and practices [10].

3.5. Biosafety in India

Biosafety in India is primarily focused on genetically modified (GM) agricultural research and ensuring environmental safety. This is evidenced by the Indian definition of biosafety as “the need to protect the environment including human and animal health from the possible adverse effects of the Genetically Modified Organisms (GMOs) and products derived from the use of modern biotechnology.” In India, the Ministry of Environment, Forests, and Climate Change (MoEFCC) along with Ministry of Science Technology are responsible to protect the environment form hazardous materials. There is a guidelines and handbook for institutional biosafety committee and biosafety officer in the country. According to the guidelines, “the biosafety officer should be adequately trained and be able to offer advice on specialized containment requirements.” Institutional biosafety committees are responsible for every facility working with Genetic Modified Organisms (GMOs). These committees are authorized to approve laboratory studies, excluding field trials and hazardous genetic experiments or methods. Each committee is comprised of academics, researchers

from the institute, including the head of institution and a medical expert. Even though there are various safety guidelines, there is no strict rule enforcing these guidelines in the country. Also, the safety awareness and biosafety practices are low and inadequate training programs for laboratory employees. Most of laboratory users dispose biological waste directly into regular household waste disposal systems. In most of the laboratories, biosafety cabinets (BSC) usage is inappropriate and regularly not maintained [4, 9 & 11].

3.6. Biosafety in Pakistan

The cross-sectional study done on clinical laboratory workers in Pakistan shows that about 31.9% of laboratory workers from all provinces did not use any kind of personal protective equipment in the laboratory. Although fire-extinguisher, biosafety cabinets and a separate place for eating and drinking are the desirable requirement for laboratory biosafety, fire-extinguishers were not available in 76.3% of cases, and 83% of laboratories were without biosafety cabinets.

Table 1: Personal protective equipment, fire-extinguishers, biosafety cabinets, separate place for eating and drinking, SOPs, accident records and biosafety training.

	Overall (N=1782)		**Province**							
			Punjab (N=907)		Sindh (N=375)		Balochistan (N=250)		NWFP* (N=250)	
	N	%	N	%	N	%	N	%	N	%
Which safety precaution do you take during your work in the laboratory?										
None	568	31.9	258	28.4	134	35.7	80	32.0	96	38.4
Does your laboratory have fire-extinguisher, fire blanket?										
No	1359	76.3	658	72.5	286	76.3	203	81.2	212	84.8
Yes	423	23.7	249	27.5	89	23.7	47	18.8	38	15.2
Do you use safety cabinet?										
No	1479	83.0	726	80.0	302	80.5	239	95.6	212	84.8
Yes	303	17.0	181	20.0	73	19.5	11	4.4	38	15.2
Is there any separate place for eating and drinking in the laboratory?										
No	1253	70.3	648	71.4	213	56.8	177	70.8	215	86.0
Yes	529	29.7	259	28.6	162	43.2	73	29.2	35	14.0
Do you have SOPs/ BOPs (standard/ basic operating procedures) in your laboratory?										
No	1202	67.5	498	54.9	272	72.5	239	95.6	193	77.2
Yes	580	32.5	409	45.1	103	27.5	11	4.4	57	22.8
Is your laboratory maintaining accident records?										
No	1591	89.3	810	89.3	325	86.7	239	95.6	217	86.8
Yes	191	10.7	97	10.7	50	13.3	11	4.4	33	13.2
Do you have any training on biosafety and bio security?										
No	1500	84.2	736	81.1	320	85.3	215	86.0	229	91.6
Yes	282	15.8	171	18.9	55	14.7	35	14.0	21	8.4

Majority of the technicians from all provinces had no separate place for eating and drinking. 89.3% of the laboratories did not maintain any accident records and, 84.2% of the technicians did not have any training in biosafety. In the country, 67.5% of the laboratories are operating without a written standard operating procedure (table1) [3]. Similar study done on clinical laboratory technician in Pakistan shows that up to 36.2% of laboratory technicians discard used syringes into municipal dustbins due to non-availability of sharps disposal boxes. There is no biosafety officer to provide work activities, procedures, equipment, storage, material transfer and transport, and proper destruction of biological materials for the lab [12].

3.7. Biosafety in Nigeria

The cross-sectional survey on status of laboratory biosafety and biosecurity in veterinary research facilities in Nigeria shows that 79.7% of the respondents reporting the use of PPE, and 63.5%, 67.6% lack access to biosafety facilities and biosafety cabinets, respectively. The country has biosafety regulation in place, however majority of the respondents (71.6%) were unaware of presence of the law. Only four of the 19 facilities surveyed (16.2%) had biosafety officers in their institutions. However, the role of biosafety officer is very important to supervise and train staff in laboratory biosafety (table2) [13]. Similar survey on biosafety practices of clinical laboratory personnel in four selected clinical laboratories in Nigeria reveals that appropriate waste disposal is a major problem in the country. Most laboratories dispose biohazards waste in general waste dumps. Standard operating procedures were not available in 67.3% of laboratories; and there was no record keeping with respect to accidents in 83.4% of samples. 82.4% of laboratory personnel hadn't been provided formal biosafety training [14].

Table 2: Status of laboratory biosafety in veterinary research facilities in Nigeria

Laboratory biosafety status	N	%
Proper use of personal protective equipment		
Yes	59	79.7
No	15	20.3
Availability of biosafety facilities		
Yes	27	36.5
No	47	63.5
Availability of biosafety cabinets		
Yes	24	32.4
No	50	67.6
Biosafety regulation awareness		
Yes	21	28.4
No	53	71.6
Facilities appointed biosafety officers		
Yes	4	16.2
No	15	83.8

3.8. Biosafety in Sudan

Prospective cross-sectional study of evaluation of laboratory biosafety in Khartoum state primary health center in Sudan shows none of the laboratories have a biosafety officer nor did any of the staff have biosafety training. From 33 only 8 (24.2%) laboratories have written standard operating procedures; and 6 (18.2%) reported laboratory accidents. Only one laboratory (3%) has a separate room for eating and drinking to the staff. Fire-extinguisher were not available in 97.0% of health care centers and 93.9% of laboratories were without boisafety cabinets. The personal protective equipment is minimal for the staff; there are no safety glasses, face shields and clothes for biological and radioactive materials. Most laboratories dispose biohazards waste in general waste dumps. Generally, in Khartoum state primary health center, poor laboratory practices and biosafety measures were observed due to lack of concern toward the job [15].

3.9. Biosafety in Ethiopia

Ethiopia ratified biosafety law firm for Genetically Modified Organism (GMO) regulation systems on September 9, 2009 and made an amendment to some of the laws on August 14, 2015. Its drafting process led by the country's Environmental Protection Authority, now named as Ministry of Environment and Forest that was judged as biased, focusing only on protecting the environment from potential risks of GMOs, giving little attention to prevent laboratory acquired infection, and their unintended impact on human health. Despite Ethiopia has biosafety regulation, there is no law that enforce its implementation in the country. Thus, most clients are not aware of the presence of the regulation. Person who carries- out activity in the laboratory with pathogenic micro-organisms is not legally insured in health [5, 16]. Procurement system of the country for public laboratory facilities, devices and personal protective equipment is offering suppliers through open bid on different Medias. The bidding style consider only the least or minimum price that company could offer should be accepted. Such kind of purchasing system will bring less quality laboratory materials, and procurement process will take long time to pass through much bureaucracies. Hence, those materials that passed through procurement process are not appropriate to use, and affect work quality and performance of employee's. It also contributes in high magnitude of work related health risks in the country. Therefore, it is more appropriate to follow quality oriented laboratory item purchasing system than looking for low price purchase [17].

3.9.1. Ethiopian Institute of Agricultural Research (EIAR)

In the case of Ethiopian Institute of Agricultural Research, neither laboratory manual nor report incorporates biosafety issues; even the availability of laboratory safety guidelines is limited within the institute. The institute lacks both safety officer and biosafety officer that supervise laboratory safety and the working environment in all concerning biosafety questions. Biosafety training programs were inadequate for laboratory employees. The whole laboratories dispose biological hazards waste in general waste dumps. Each laboratory operates with a written standard operating procedure developed by lab heads. The initial phase in establishing a biosafety program in any laboratory is the development of standard operating procedures (SOPs) that will act as a guide. Such SOPs will dictate practice pertaining to the handling of different samples, disposal of wastes generated in the laboratory and also the use of personal protective equipment. Provision of personal protective equipment is

very important; attitude like wearing lab coat, using gloves, hand wash, safety glasses, face shields and close-toed foot wear will help to protect workers and decrease injuries and infection in the working area. However, the current situation in the institute reveals that the availability of personal protective equipment for the laboratory workers is low and most of the equipments are inappropriate to use. Biosafety cabinet usages are inappropriate and not regularly maintained. Dangerous biological agents that have the potential to be inhaled during experimental and clinical procedures require additional biosafety practices and measures, such as biological safety cabinet, one of the most important pieces of laboratory equipment to reduce the risk of inhalation exposure. On top of that, the experience of accident record and report was low in each laboratory. In general, at least there is no first aid utensils in most of the laboratories in the Institute [18].

3.9.2. Ethiopian conformity Assessment Enterprise

In Ethiopian conformity Assessment Enterprise, safety guideline is available without consideration of biosafety issues in the laboratory. Neither safety officer nor biosafety officer is appointed by the enterprise. There was low biosafety awareness and practices, and in adequate training of biosafety for laboratory personnel. Laboratory personnel use appropriate personal protective equipment when entering and operating laboratory activities. The enterprise has developed its own laboratory standard operating procedures, but not well documented. There is few biosafety cabinets in the lab, even the existing once are not regularly checked and maintained. The laboratory disposes bio hazard wastes in general waste dumps (Ethiopian conformity Assessment Enterprise, personal observation, May 2019).

3.9.3. Ethiopian Public Health Institute

A report from Ethiopian Public Health Institute indicate that the institute has received a biosafety level three mobile laboratory, which has been delivered by Federal Ministry of Health and United Nations Country Team (UNCT), on November 10, 2016, Addis Ababa, Ethiopia. This biosafety level three mobile laboratory is a timely boost to the institute's national capacity to investigate the cause of emerging and reemerging highly infectious pathogens. The institute is working on the strengthening of laboratory infrastructure at national and regional level. Even though, laboratory biosafety issues were supervised by Quality Management Representatives, the institute lack dedicated biosafety officer who will document untoward events and near misses, ensure vaccine are taken appropriately and report back to the laboratory head on safe practice amongst personnel. Biosafety on-job training has been given to each laboratory workers annually without consideration for new comers. Formal biosafety training should be essential to new recruits before starting their laboratory activities. However, this training was not applicable due to resource scarcity in the institute. There exists abundant inappropriate Personal protective equipment, and most of laboratory workers did not use while working with pathogenic organisms. Biosafety cabinets are periodically maintained and certified annually by independent third-party professional. There was no trend of accident or injury recording and report in each laboratory. Poor toxic medical waste disposal was seen within the institute due to lack of appropriate waste disposal dump (Eyob Abera, personal communication, May 2019).

3.9.4. National Animal Health Diagnostic and Investigation Center

In National Animal Health Diagnostic and Investigation Center (NAHDIC) the laboratory biosafety manual indicated that biosafety officer was appointed for laboratories. These biosafety officers were who hold a degree in the field of microbiologist, veterinarian and chemist, and responsible for biosafety activities besides to their main job. Dual responsibility will affect expert's performance and work, and then need qualified professionals in the field to ensure biosafety efficiency and effectiveness. Each laboratory personnel use appropriate personal protective equipment while working with pathogenic organisms. The biological wastes categorized into hazardous and non-hazardous based on its degree of risk. Those that are highly risky decontaminated with autoclave and burn in incinerator and the other disposed in general waste dump. Such kind of waste disposal is a good starting in the center, and will bring an initiation for other sectors. Biosafety devices and cabinets were annually maintained and certified by independent third-party professionals to protect laboratory workers from pathogenic exposure. Biosafety training programs were inadequate for laboratory workers due to scarce resources within the center. The laboratory personnel working with pathogenic organisms did not periodically checked-up medically and insured in health due to lack of legal enforcement in the center. Thus, it is not possible to mention health impact of workers in such laboratories since there was no established periodical check-up in the center. There was also no accident or injury recording and report from each laboratory (NAHDIC, personal observation, June 2019).

4. Conclusion and recommendation

This review provided valuable information regarding the laboratory biosafety status of Ethiopia in considering international biosafety capabilities and practices. The laboratory biosafety has been given high attention in developed countries, while most of developing or middle-income countries do not have sustainable means to safely work with these pathogenic micro-organisms in laboratories. The absence of detailed biosafety legal frame-work for laws and regulations, and its enforcement was one of the challenges facing laboratory workers in Ethiopia. There was in-adequate availability and access to biosafety devices and personal protective equipment, as well as low awareness by most of clients regarding national law and associations pertaining to laboratory biosafety. Therefore, successive training to create public awareness on biosafety law, rules and regulation is very much relevant. The absence or not appointing a biosafety officer is still a major problem in Ethiopia. The laboratory personnel lack formal training in laboratory biosafety and laboratory accidents or injuries was not properly reported. There was poor biohazard waste disposal from each laboratory. The country lacks health insurance for most of laboratory workers, which in reality; is very much pertinent to be considered. Current laws on biosafety should be revised to include a laboratory biosafety component and should go in-line with internationally accepted biosafety guidelines and policies. There is a need to establish continuous funding sources to operate and maintain containment facilities. Existence of the basic biosafety devices and appropriate personal protective equipment are essential to protect workers from pathogens. Regular training on biosafety is needed for laboratory workers to make new employee aware of the biosafety measures as well as to update their knowledge of biosafety. Appointing dedicated and qualified biosafety officer in each laboratory should be a top priority to ensure laboratory biosafety. Establishing appropriate national level biohazard waste disposal dump is crucial for human and environmental safety. To address the biosafety issues, proper attention and contribution from policy-makers, researchers, laboratory technologist, custodians, and other stakeholders are needed. The paucity of information on laboratory biosafety in Ethiopia implies that more research work is required to

generate relevant data for the public and policy-makers.

References

[1]. World Health Organization. (2006). "Biorisk management: Laboratory Biosecurity Guidance". *Geneva*. [on-line], pp. 1-41. Available at http://www.who.int/ihr/publications/WHO_CDS_EPR_2006_6/en/ [Sept.6, 2006].

[2]. S. Kumar. "Biosafety Issues in Laboratory Research." *Biosafety*, vol. 01, pp. 1–2, 2012.

[3]. S. Nasim et al. "Biosafety perspective of clinical laboratory workers: A profile of Pakistan." *J. Infect. Dev. Ctries.*, vol. 6, pp. 611–619, 2012.

[4]. K. P. Kandel, B. B. Neupane, and B. Giri. "Status of chemistry lab safety in Nepal." *PLoS One*, vol. 12, pp. 1–10, 2017.

[5]. A. Abraham. "Toward a workable biosafety system for regulating genetically modified organisms in Ethiopia: balancing conservation and competitiveness." *GM Crops Food*, vol. 4, pp. 28–35, 2013.

[6]. B. Johnson and R. Casagrande. "Comparison of international guidance for biosafety regarding work conducted at biosafety level 3 (BSL-3) and gain-of-function (GOF) experiments." *Appl. Biosaf.*, vol. 21, pp. 128–141, 2016.

[7]. FCCB. "Ordinance on Handling Organisms in Contained Systems - Legislation," pp. 1–32, 2012.

[8]. M. O. R. Respirator. " Cases of SARS report." *Cdc*, pp. 2003–2005, 2004.

[9]. H. Security. "National Biosafety Systems." *UPMC*, July 2016.

[10]. S. Government, "Biological Agents and Toxins Act: the Statutes of the Republic of Singapore - PATENT ACT." *Law.Rev. Commi.*, vol. 24, 2015.

[11]. INSA. " Challenges of Emerging Infections and Global Health Safety." INDO-US Workshop, New Delhi, India, 2014.

[12]. S. Nasim et al. "Practices and Awareness regarding Biosafety Measures among Laboratory Technicians Working in Clinical Laboratories in Karachi, Pakistan." *Appl. Biosaf.*, vol. 15, pp. 172–179, 2010.

[13]. I. A. Odetokun, A. T. Jagun-Jubril, B. A. Onoja, Y. S. Wungak, I. A. Raufu, and J. C. Chen. "Status of Laboratory Biosafety and Biosecurity in Veterinary Research Facilities in Nigeria." *Saf. Health Work*, vol. 8, pp. 49–58, 2017.

[14]. S. E et al. "A Survey of Biosafety Practices of Clinical Laboratory Personnel in Four Selected Clinical

Laboratories." *Med. Saf. Glob. Heal.*, vol. 04, 2015.

[15]. AF. Idris and M. Bayoumi. "Evaluation of Laboratory Biosafety in Khartoum State Primary Health Care Centers." *Med. Saf. Glob. Heal.*, vol. 5, pp. 917–925, 2016.

[16]. Council of Ministres Regulation on No.199/2013 council. "Federal Negarit Gazette." *Fed. Negarit Gaz.*, pp. 3–10, 2014.

[17]. Public Procurement and Property Administration Agency, (2010). "Public Procurement Manual Ahmaric." *Fed. Negarit Gaz.*[on-line], pp. 1–290. Available at: http://www.ppa.gov.et/manual.pdf

[18]. S. Abera. Procedures , Equipment use , and Safety Considerations for Molecular Biology Laboratory Manual. Addis Ababa. EIAR. 2017.

[19]. US Department of Health and Human Services. "Biosafety in Microbiological and Biomedical Laboratories (BMBL)." *Public Heal. Serv.*, vol. 5, pp. 1–250, 1999.

[20]. WHO. "Laboratory biosafety manual," *World Heal. Organ.*3rd ed. Geneva: World Health Organization, 2004, pp. 1–178.

Appendix: Supplementary Data

Table 3: Summary of recommended Biosafety Levels for Infectious Agents [19]

BSL	Agents	Practices	Primary Barriers and Safety Equipment	Facilities (Secondary Barriers)
1	Not known to consistently cause diseases in healthy adults	Standard microbiological practices	▪ No primary barriers required. ▪ PPE: laboratory coats and gloves; eye, face protection, as needed	Laboratory bench and sink required
2	▪ Agents associated with human disease ▪ Routes of transmission include percutaneous injury, ingestion, mucous membrane exposure	BSL-1 practice plus: ▪ Limited access ▪ Biohazard warning signs ▪ "Sharps" precautions ▪ Biosafety manual defining any needed waste decontamination or medical surveillance policies	Primary barriers: ▪ BSCs or other physical containment devices used for all manipulations of agents that cause splashes or aerosols of infectious materials ▪ PPE: Laboratory coats, gloves, face and eye protection, as needed	BSL-1 plus: ▪ Autoclave available
3	Indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure	BSL-2 practice plus: ▪ Controlled access ▪ Decontamination of all waste ▪ Decontamination of laboratory clothing before laundering	Primary barriers: ▪ BSCs or other physical containment devices used for all open manipulations of agents ▪ PPE: Protective laboratory clothing, gloves, face, eye and respiratory protection, as needed	BSL-2 plus: ▪ Physical separation from access corridors ▪ Self-closing, double-door access ▪ Exhausted air not recirculated ▪ Negative airflow into laboratory ▪ Entry through airlock or anteroom ▪ Hand washing sink near laboratory exit
4	▪ Dangerous/exotic agents which post high individual risk of aerosol-transmitted laboratory infections that are frequently fatal, for which there are no vaccines or treatments ▪ Agents with a close or identical antigenic relationship to an agent requiring BSL-4 until data are available to redesignate the level ▪ Related agents with unknown risk of transmission	BSL-3 practices plus: ▪ Clothing change before entering ▪ Shower on exit ▪ All material decontaminated on exit from facility	Primary barriers: ▪ All procedures conducted in Class III BSCs or Class I or II BSCs in combination with full-body, air-supplied, positive pressure suit	BSL-3 plus: ▪ Separate building or isolated zone ▪ Dedicated supply and exhaust, vacuum, and decontamination systems ▪ Other requirements outlined in the text

Table4: Summary of Recommended Animal Biosafety Levels for Activities in which experimentally or Naturally Infected Vertebrate Animals are used [19]

BSL	Agents	Practices	Primary Barriers and Safety Equipment	Facilities (Secondary Barriers)
1	Not known to consistently cause diseases in healthy adults	Standard animal care and management practices, including appropriate medical surveillance programs	As required for normal care of each species ▪ PPE: laboratory coats and gloves; eye, face protection, as needed	Standard animal facility: ▪ No recirculation of exhaust air ▪ Directional air flow recommended ▪ Hand washing sink is available
2	▪ Agents associated with human disease ▪ Hazard: percutaneous injury, ingestion, mucous membrane exposure	ABSL-1 practice plus: ▪ Limited access ▪ Biohazard warning signs ▪ "Sharps" precautions ▪ Biosafety manual ▪ Decontamination of all infectious wastes and animal cages prior to washing	ABSL-1 equipment plus primary barriers: ▪ Containment equipment appropriate for animal special ▪ PPE: Laboratory coats, gloves, face, eye and respiratory protection, as needed ▪	ABSL-1 plus: ▪ Autoclave available ▪ Hand washing sink available ▪ Mechanical cage washer recommended ▪ Negative airflow into animal and procedure rooms recommended
3	Indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure	ABSL-2 practice plus: ▪ Controlled access ▪ Decontamination of clothing before laundering ▪ Cages decontaminated before bedding is removed ▪ Disinfectant foot bath as needed	ABSL-2 equipment plus: ▪ Containment equipment for housing animals and cage dumping activities ▪ Class I, II or III BSCs available for manipulative procedures (inoculation, necropsy) that may create infectious aerosols ▪ PPE: Appropriate respiratory protection	ABSL-2 facility plus: ▪ Physical separation from access corridors ▪ Self-closing, double-door access ▪ Sealed penetrations ▪ Sealed windows ▪ Autoclave available in facility ▪ Entry through ante-room or airlock ▪ Negative airflow into animal and procedure rooms ▪ Hand washing sink near exit of animal or procedure room
4	▪ Dangerous/exotic agents which post high risk of aerosol transmitted laboratory infections that are frequently fatal, for which there are no vaccines or treatments ▪ Agents with a close or identical antigenic relationship to an agent requiring BSL-4 until data are available to redesignate the level ▪ Related agents with unknown risk of transmission	ABSL-3 practices plus: ▪ Entrance through change room where personal clothing is removed and laboratory clothing is put on; shower on exiting ▪ All wastes are decontaminated before removal from the facility	ABSL-3 equipment plus: ▪ Maximum containment equipment (i.e., Class III BSC or partial containment equipment in combination with full body, air-supplied positive-pressure suit) used for all procedures and activities	ABSL-3 facility plus: ▪ Separate building or isolated zone ▪ Dedicated supply and exhaust, vacuum, and decontamination systems ▪ Other requirements outlined in the text

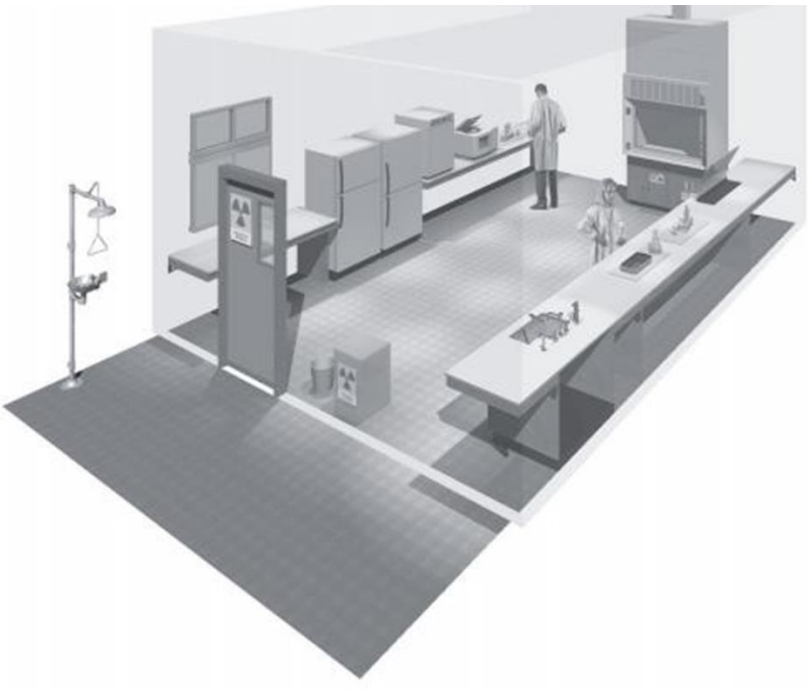

Figure 2: A typical Biosafety Level 1 laboratory

Graphics kindly provided by CUH2A, Princentor, NJ, USA [20]

- PPE: laboratory coats and gloves; eye glass and face protection needed
- Laboratory bench and sink required
- Directional airflow recommen

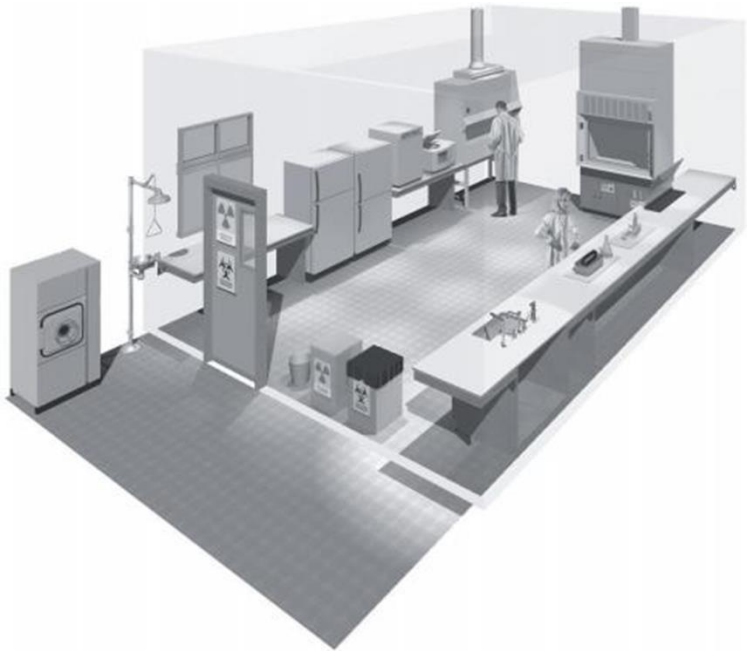

Figure 3: A typical Biosafety Level 2 laboratory

Graphics kindly provided by CUH2A, Princentor, NJ, USA [20]

- Biosafety level-1 plus:
- Biosafety cabinets
- Autoclave available
-

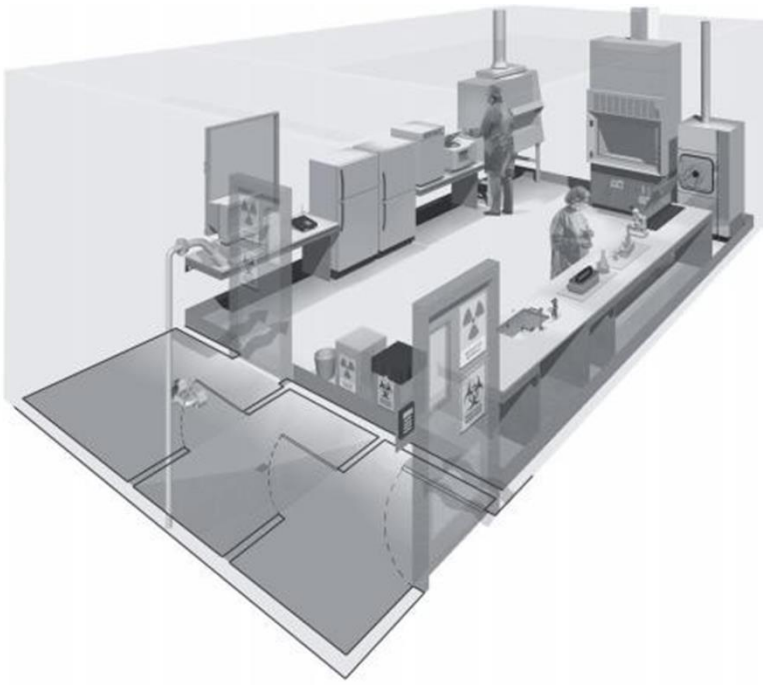

Figure 4: A typical Biosafety Level 3 laboratory

Graphics kindly provided by CUH2A, Princentor, NJ, USA [20]

- Biosafety level-2 plus:
- Physical separation from access corridors
- Self-closing, double-door access
- Sealed penetrations and windows
- Exhausted air not recirculated
- Negative airflow into laboratory
- Entry through airlock or anteroom
- Hand washing sink near laboratory exit

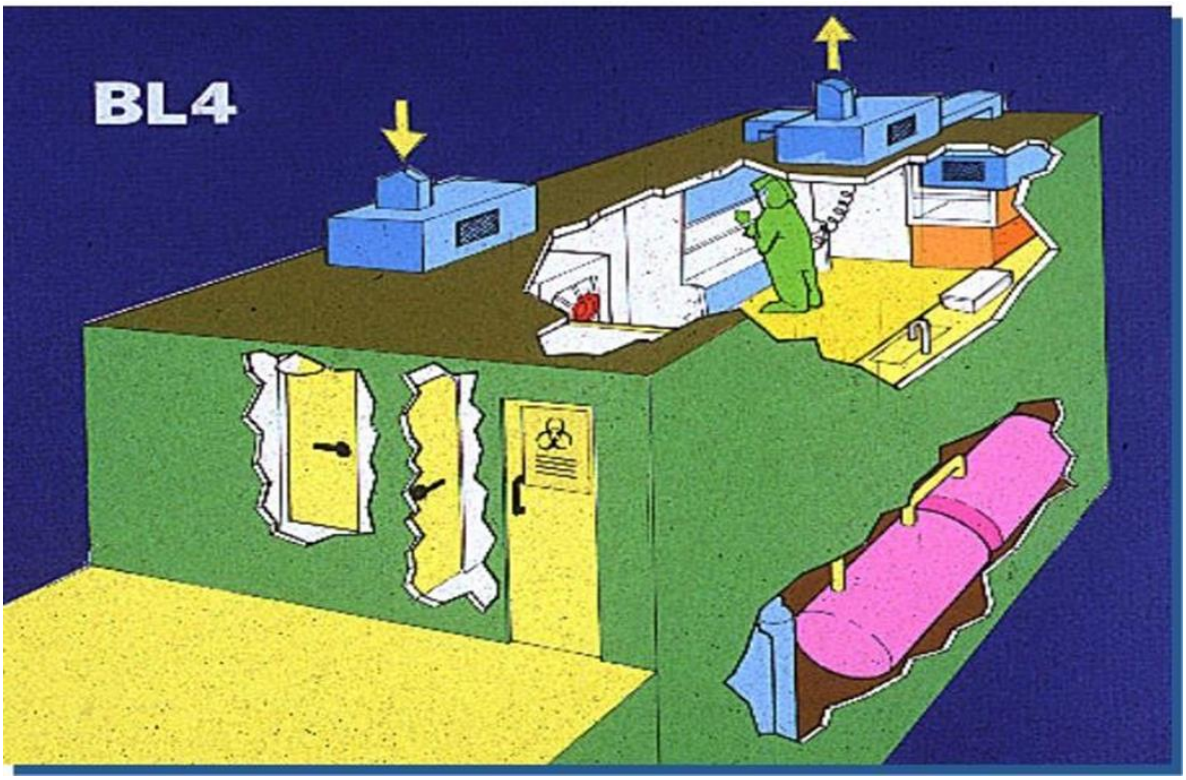

Figure 5: A typical Biosafety Level 4 laboratory

Graphics kindly provided by CUH2A, Princentor, NJ, USA [20]

- Biosafety level-3 plus:
- Separate building or isolated zone
- Dedicated supply and exhaust, vacuum, and decontamination systems